

What is claimed is:

1. A magnetically navigable endoscope system comprising:
an endoscope having a proximal end and a distal end, the distal end having a magnetic body;
an imaging device which transmits an image, associated with the distal end;
5 a display component for displaying the image;
a magnetic field generating apparatus for generating a magnetic field to move the magnetic body and thus the distal end of the endoscope;
a controller coordinated with the display for controlling the magnetic field generating apparatus to apply a magnetic field to change the position of the magnetic body and thus the 10 position of the distal end of the endoscope.

~~1.1~~ 2. The magnetically navigable endoscope system according to claim 1 wherein the controller controls the magnetic field generating apparatus to apply a magnetic field of a specific direction to change the orientation of the magnetic body and thus the orientation of the distal end of the endoscope.

15 3. The magnetically navigable endoscope system according to claim 1 wherein the controller controls the magnetic field generating apparatus to apply a magnetic gradient to move the magnetic body and thus the location of the distal end of the endoscope.

20 4. The magnetically navigable endoscope system according to claim 1 wherein the controller controls the magnetic field generating apparatus to apply a magnetic field and a magnetic gradient to apply a magnetic field of a specific direction to change the orientation of the magnetic body and to apply a magnetic gradient to move the magnetic body and thus the orientation and location of the distal end of the endoscope.

5. The magnetically navigable endoscope system according to claim 1 wherein the controller is on the endoscope, adjacent the proximal end.

6. The magnetically navigable endoscope system according to claim 1 wherein the controller is operable in at least two mutually perpendicular directions, movement in which causes the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in two mutually perpendicular directions.

7. The magnetically navigable endoscope system according to claim 1 wherein the display includes indicia indicating an orientation of the displayed image, and wherein the controller is operable in at least two mutually perpendicular directions, and movement in the

first direction causes the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in a first plane relative to the indicia, and movement in the second direction causes the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in a second plane, perpendicular to the first place.

8. The magnetically navigable endoscope system according to claim 7 wherein the first plane is aligned with the indicia.

9. The magnetically navigable endoscope system according to claim 6, wherein the display has vertical and horizontal directions, and wherein the movement of the controller in one of the mutually perpendicular directions causes the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in the vertical direction as displayed on the display, and wherein the movement of the controller in the other of the mutually perpendicular direction causes the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in the horizontal direction as displayed on the display.

10. The magnetically navigable endoscope system according to claim 9 further comprising a signal processor orienting the image on the display so that the vertically "up" direction of the image is oriented at the top of the display regardless of the actual orientation of the axis of the endoscope.

11. The magnet assembly according to claim 1 wherein the endoscope includes a magnet channel, and wherein there is at least one magnet body disposed in the magnet channel adjacent the distal end.

12. The magnet assembly according to claim 1 wherein there are a plurality of magnet bodies in the distal end portion of the endoscope.

13. The magnet assembly according to claim 1 wherein the magnet body comprises a permanent magnetic material.

14. The magnet assembly according to claim 1 wherein the magnet body comprises a permeable magnetic material.

15. A magnetically navigable endoscope system comprising:

an endoscope having a proximal end and a distal end, the distal end having a magnetic body;

a component which transmits an image, associated with the distal end;

5 a two-dimensional display for displaying the image from the image-transmitting component, the display having a vertical and horizontal direction;

a magnetic field generating apparatus for generating a magnetic field to orient the magnetic body and thus the distal end of the endoscope;

10 a controller for controlling the magnetic field generating apparatus to selectively apply to apply a magnetic field to change the position of the magnetic body and thus the position of the distal end of the endoscope, the controller operable in at least two mutually perpendicular directions, movement of the controller in one of the mutually perpendicular directions causing the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in the vertical direction as displayed on the display, and

15 wherein the movement of the controller in the other of the mutually perpendicular directions causes the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in the horizontal direction as displayed on the display.

16. A method of magnetically navigating an endoscope, the method comprising displaying an image from the distal end of the endoscope on a display, the display including an orientation indicia; and

5 operating a controller to control the application of a magnetic field to the distal end of the endoscope, the controller being operable in at least two mutually perpendicular directions, movement of the controller in one of the mutually perpendicular directions causing the magnetic field generating apparatus to apply a magnetic field to move the distal end of the endoscope in a first plane relative to the orientation indicia on the display, and wherein the movement of the controller in the other of the mutually perpendicular directions causes the 10 magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in a second plane, perpendicular to the first plane.

17. A method of magnetically navigating an endoscope, the method comprising displaying an image from the distal end of the endoscope on a display operating a controller to control the application of a magnetic field to the distal end of the endoscope, the controller being operable in at least two mutually perpendicular directions,

5 movement of the controller in one of the mutually perpendicular directions causing the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in the vertical direction as displayed on the display, and wherein the movement of the controller in the other of the mutual perpendicular directions causes the magnetic field generating apparatus to change the magnetic field to move the distal end of the endoscope in
10 the horizontal direction as displayed on the display.

18. A magnetically navigable endoscope system comprising:

an endoscope having a proximal end and a distal end, the distal end having a magnetic body;

a component which transmits an image, associated with the distal end;

5 a two-dimensional display for displaying the image from the image-transmitting component, the display having a vertical and horizontal direction;

a magnetic field generating apparatus for generating a magnetic field to move the magnetic body and thus the distal end of the endoscope; and

10 a controller for identifying the volume over which to orient the endoscope and controlling the magnetic field generating apparatus to selectively change the magnetic field to change the orientation of the magnetic body and thus the distal end of the endoscope over the specified volume.

19. A method of magnetically controlling an endoscope in body lumens and cavities, the method comprising:

localizing the distal end of an endoscope;

registering the location of the distal end of the endoscope to a pre-operative image set

5 such as an MR or CT;

identifying a direction on the pre-operative image set; and

controlling the magnetic field generating apparatus to move the distal end of the endoscope in the identified direction.

20. The method of magnetically controlling an endoscope according to claim 19
10 wherein the magnetic field generating apparatus generates a magnetic field in the identified direction to orient the distal end of the endoscope in the identified direction.

21. The method of magnetically controlling an endoscope according to claim 19
wherein the magnetic field generating apparatus generates a magnetic field with a gradient in
the identified direction to advance the distal end of the endoscope in the identified direction.

15 22. The method of magnetically controlling an endoscope according to claim 19 wherein the magnetic field generating apparatus generates a magnetic field with a field direction and gradient in the identified direction to orient and advance the distal end of the endoscope in the identified direction.

20 23. A method of magnetically controlling an endoscope in body lumens and cavities, the method comprising:

localizing the distal end of an endoscope;

registering the location of the distal end of the endoscope to a pre-operative image set such as MR or CT;

programming a volume over which to move the endoscope; and

25 25. controlling the magnetic field generating apparatus to move the distal end of the endoscope in the specified volume.

24. A method of magnetically navigating an endoscope in a body lumen or cavity with an applied magnetic field, the method comprising:

displaying an image from the distal end of the endoscope in an orientation relative to a directional control such that operation of the directional control in a selected direction 5 relative to the displayed image causes the applied magnetic field to change to move the distal end of the endoscope in a corresponding direction on the display, and

operating the directional control corresponding to the desired direction as displayed upon the displayed image to apply a magnetic field to move the distal end in the desired direction as displayed upon the displayed image.

10 25. The method according to claim 24 wherein operating the directional control applies a magnetic field in the selected direction to orient the distal end of the endoscope in the desired direction.

15 26. The method according to claim 24 wherein operating the directional control applies a magnetic field with a gradient in the selected direction to advance the distal end of the endoscope in the desired direction.

27. The method according to claim 24 wherein operating the directional control applies a magnetic field in a selected direction, and with a gradient in the selected direction to orient and advance the distal end of the endoscope in the desired direction.

28. The method according to claim 24 wherein the step of displaying an image 20 includes periodically reorienting the image by

operating the directional control to change the applied magnetic field to move the distal end of the endoscope.

identifying the direction of movement of the distal end of the endoscope on the display; and

25 reorienting the image on the display so that the direction of movement caused by operating the control intuitively corresponds to the directions on the displayed image. ^{AB}

29. The method according to claim 24 wherein the endoscope is navigated through one of the lungs, the urinary tract, or the gastrointestinal tract, brain, and heart.

30. A magnetically navigable endoscope system comprising:

an endoscope having a proximal end and a distal end, the distal end having a magnetic body;

an imaging device which transmits an image, associated with the distal end;

5 a plurality of sensors triggered by contact with the wall of a body lumen or cavity, distributed around the distal end;

a two-dimensional display for displaying the image from the imaging device, the display having a vertical and horizontal direction;

10 a magnetic field generating apparatus for generating a magnetic field to orient the magnetic body and thus the distal end of the endoscope;

a computer which monitors feedback of the wall contact sensors and adjusts the magnetic field generating apparatus to selectively modify the magnetic field to change the orientation of the magnetic body such that the endoscope is automatically positioned within the body lumen or cavity.

31. The system according to claim 30 wherein the computer that monitors the feedback of the wall contact sensors adjusts the magnetic field generating apparatus to selectively modify the magnetic field to position the endoscope in generally the center of the body lumen or cavity.

32. The system according to claim 30 wherein the computer that monitors the feedback of the wall contact sensors adjusts the magnetic field generating apparatus to selectively modify the magnetic field to position the endoscope generally adjacent a selected wall of the body lumen or cavity.

33. The system according to claim 30 further comprising an advancing mechanism for advancing the endoscope.

34. The system according to claim 33 further comprising an interlock for preventing operation of the advancing mechanism when a predetermined number of wall-sensors are triggered.

35. A magnetically controllable endoscope having a proximal end, a distal end, a magnetic body associated with the distal end, the endoscope having at least two sections along its length of different flexibilities of its length.

36. The magnetically controllable endoscope according to claim 35, wherein the endoscope comprises a proximal section and a distal section, and wherein the distal most section is more flexible than the proximal section.

37. The magnetically controllable endoscope according to claim 35 wherein the
5 magnetic body comprises a permanent magnetic material.

38. The magnetically controllable endoscope according to claim 35 wherein the magnetic body comprises a permeable magnetic material.

39. The magnetically controllable endoscope according to claim 35 further comprising a binder in the endoscope, and wherein the regions of different flexibility are formed by selective leaching of the binder.

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